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The Role of Star Formation in Nitrogen Abundance Evolution

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Abstract. We analyze the evolution of nitrogen resulting from a set of spiral and irregular galaxy models computed for a large number of input mass radial distributions and with various star formation efficiencies. We show that our models produce a nitrogen abundance evolution in good agreement with the observational data. Differences in the star formation histories of the regions and galaxies modeled are essential to reproduce the observational data in the N/O–O/H plane and the corresponding dispersion.

1. The Primary Nitrogen

When observations, especially metal-poor galaxy data, are plotted in the plane N/O vs O/H, it is evident that a primary N contribution must exist. Applying the classical Closed Box Model, the points may be limited by three curves, as plotted in Fig. 1a: 1) the one called NS, which shows the evolutionary tracks of N/O when N needs a seed of O to be created: $\mathrm{N/O} = p_{\mathrm{N}}(\mathrm{O})/p_{\mathrm{O}} \propto \mathrm{O}$; 2) the one called NP that appear when N is created directly from H or He: $\mathrm{N/O} = p_{\mathrm{N}}/p_{O} =$ constant; 3) NS + NP, when both contributions exist, which seems to be the apparent behavior reproduced by the data.

It is, however, necessary to take into account three factors not included in that simple scenario: 1) the mean lifetimes of stars, 2) the star formation efficiency, or the existence of different star formation histories or star formation rates in different galaxies or objects, and 3) the dependence of stellar yields. If the primary nitrogen is ejected by low and intermediate mass (LIM) stars, it will appear in the interstellar medium very abruptly after a time delay, which means when O/H has already reached a certain value. Obviously, this level will be higher or lower depending on the mean lifetime of these stars. But it also depends on the efficiency in forming stars: for a high efficiency the NP will appear later, or at higher O/H, than for a low one. Both facts produce a certain dispersion in the resulting abundances. Besides that, the metallicity-dependent stellar yields produce tracks that are elongated in comparison with that produced when only one yield value is used (for details see Mollá et al. 2006).

2. The Multiphase Chemical Evolution Model Grid

We have computed a grid of models (Mollá & Díaz 2005) with 44 theoretical galaxies of different total masses and ten possible efficiencies to form stars in each one. We have used the yields from Woosley & Weaver (1995) for massive stars and those from Gavilán, Buell & Mollá (2005) for LIM stars, which give results for our Galaxy (Gavilán, Mollá & Buell 2006) in excellent agreement with halo stars data (Israelian et al. 2004; Spite et al. 2005).

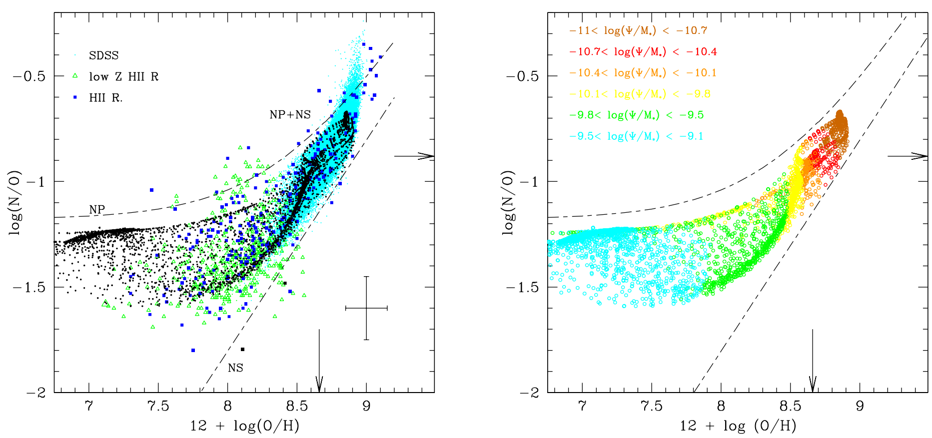

Figure 1. The relative abundance log(N/O) vs the oxygen abundance 12 + log(O/H). *Left:* Our model results for the present time as small black dots compared with data (colors as labeled) from authors given in Table 1 of Mollá et al. (2006). *Right:* The same results represented according to their present specific star formation rate, as labeled.

The results obtained (Mollá et al. 2006) for the present time are compared with observations in Figure 1 (*left*). The position of a galaxy in the N/O–O/H plane depends on the star formation histories and/or on the actual star formation rate as we may see in Fig. 1 (*right*): if the star formation occurred as a strong and early burst, with a low rate at the present time compared with the past maximum (red dots), the evolutionary track in that plane appears as very secondary and O/H and N/O are high. When the star formation occurs quietly with a rate higher now than in the past (cyan dots), the track is almost flat with low O/H and N/O abundances. This way we conclude that our grid of models reproduces and explains very well most of observational data in the N/O–O/H plane.

References

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